BIO Web of Conferences **52**, 00010 (2022) https://doi.org/10.1051/bioconf/20225200010
*FIES 2022*

# Autonomous power supply of objects in rural settlements of Pavlodar region using alternative energy sources

*Altai* Alimgazin[1,*] , *Ildar* Sultanguzin[2], *Irina* Akhmetova[3], *Askhat* Berguzinov[4], *Baurzhan* Zhakisihev[1], and *Oleg* Ushchekin[3]

[1] Eurasian National University named after L.N. Gumilyov, 2, Satbaev St., Nur-Sultan, 010000, Kazakhstan
[2] Moscow Power Engineering Institute Institute, 14, Krasnokazarmennaya St., Moscow, 111250, Russian Federation
[3] Kazan State Power Engineering University, 51, Krasnoselskaya St., Kazan, Republic of Tatarstan, 420066, Russian Federation
[4] Toraighyrov University, 64, Lomov Street, Pavlodar, 140000, Kazakhstan

**Abstract.** The issues of practical application at pilot facilities in the village of Konstantinovka, Uspensky district, Pavlodar region of a specific technology are considered. It is based on an autonomous power supply complex (APSC) using geothermal wells of the region with temperatures from +25$^0$C to +42$^0$C as a low-grade heat source. The results of integrated calculations of the economic effect resulting from the introduction of the AEC supply heat to a number of social facilities (school, hospital, kindergarten, 24-apartment building, sports complex) with a total heat load of 0.683 Gcal/hour (data from the akimat of the village of Konstantinovka) are presented.

## 1 Introduction

The transition to low-carbon development and decarbonization of the national economy of Kazakhstan involves the adoption of cardinal measures to improve energy efficiency and the introduction of new low-carbon technologies [1-3].

The Republic of Kazakhstan has also joined this global process by signing and ratifying the Paris Climate Agreement and declaring at the UN Climate Ambitions Summit in December 2020 its intention to achieve carbon neutrality by 2060.

The need to take drastic measures is dictated by technological and environmental risks, the solution of which does not require delay.

According to the latest data, Kazakhstan ranks among thirty polluting countries in the global ranking [1-3].

According to The Global Carbon Atlas, Kazakhstan's contribution to global carbon dioxide emissions by the end of 2019 amounted to 314 megatons of CO2.

In terms of carbon dioxide emissions, Kazakhstan ranked 21st among more than 221 countries.

Today, coal generation accounts for over 70% of our country's generation structure. And in the next 15 years this figure is planned to be reduced to 50% through the use of the best available technologies (BAT), the active introduction of renewable energy and hydrogen energy technologies, the commissioning of new gas turbine power plants, the development of decentralized energy supply, etc.

As world experience shows, one of the most promising technologies contributing to the effective decarbonization of the national economy includes technologies related to the use of steam compression and absorption heat transformers (heat pumps, cooling machines) [2-10].

The analysis of world-famous examples of the use of heat transformers in agriculture has shown broad prospects for improving the efficiency of processes in various areas of this industry [11–14].

The technological processes of agriculture are associated with a large consumption of heat, which is largely satisfied by electricity. Agriculture also has its own large secondary thermal resources, but due to their low-temperature potential, they are poorly and not fully used.

The use of reversible heat pumps (TN) in agricultural technological processes makes it possible to use low-potential waste heat to generate the necessary heat.

On livestock farms of the agro-industrial complex, the use of refrigerating machines (HMM) is required to cool milk. Also, there is a need for hot water, which is used for technological purposes and watering livestock. It is also necessary to provide heating for individual premises of the farm, including the calf house in the maternity ward. All these operations can be performed using equipment and energy-saving technologies.

The use of new innovative energy-saving technologies using heat transformers (TN, HM) is a real way to increase the efficiency of milk cooling and reduce energy consumption by optimizing and improving the design and technological scheme of milk cooling and water heating [12, 13].

In the food industry, the use of XM is very often required for the implementation of technological processes [12–14].

* Corresponding author: alimgazin_altai@mail.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

For example, many breweries, meat and dairy plants and sausage factories have very large centralized HMS.

On the other hand, there is a great need for hot water used for various types of cleaning throughout the year. It is also necessary to provide heating of the premises.

Thus, there are all conditions for the beneficial use of TN and XM. However, we know only a few cases of their use in this area [12–14].

An example is the possibility of using TN with the simultaneous use of heat and cold during the pasteurization of liquids with their subsequent cooling.

The use of TN for the combined production of cold and heat in the food industry is also provided during the implementation of maturation processes, for example, cheeses or sausages [4, 5, 13].

For example, on dairy farms, the main share of energy consumption is the cost of electricity for the electric drive of HMS cooling freshly milked milk and for heating water for sanitary and technological needs.

The use of TN in this area allows you to simultaneously obtain the necessary cold and sanitary hot water with minimal energy consumption, which significantly affects the final cost of production.

The use of TN in dining rooms also significantly reduces the consumption of electricity for ventilation.

TN effectively solve the problems of heating greenhouses and farms. The range of application of TN is extremely wide, since their use is possible in greenhouses (for growing flowers, vegetables, ornamental plants, seedlings and seedlings), at livestock facilities and poultry farms [4, 5, 13, 14].

The use of TN in greenhouses [4, 5, 14] will dramatically reduce the cost of agricultural products.

The principle of using modern energy-saving heating and cooling technologies based on heat transformers for houses, greenhouses, animal and water complexes allows you to reduce the costs associated with fuel.

## 2 Materials and methods

Currently, in many rural settlements of the Republic of Kazakhstan, the problem of providing heat and electricity to both social facilities and agricultural sector facilities, small and medium-sized businesses is acute.

The combination of heating and cooling systems using steam compression and absorption heat transformers [2, 3] is very promising in agricultural enterprises of the Republic of Kazakhstan (farms, vegetable storages, meat and dairy complexes, greenhouses, etc.).

In accordance with the instructions of the President of Kazakhstan, the Ministry of Agriculture of the country has been successfully implementing a new special project “Auyl – El besigi” (“Aul – Cradle” within the framework of the “Spiritual Radiance” program since 2019 [15].

The villages of the Republic of Kazakhstan should have good roads, healthcare, decent education, sports centers, housing. It is planned to select 1–1.5 thousand villages from the currently existing 6,600 rural settlements and turn them into mini-towns with high standards of quality of life, which is quite possible.

The aim of the project is to modernize the socio-economic infrastructure of rural areas, which should ensure that by 2030 at least 80% live in settlements that meet modern standards of quality of life.

In many countries of the world, new heat supply systems based on thermal waters from TN have been developed and are actively used. Thermal waters can be used for heating buildings, for heating greenhouses, water in swimming pools, growing vegetables, fruits and for other purposes [4–7].

They are especially appropriate for the needs of heat supply, since thermal waters with temperatures below 45–50°C are most common, while additional high-temperature heat sources are provided, which are turned on at low outdoor temperatures. They can be peak boilers for additional heating of thermal waters, TN, electric heating installations.

In the Republic of Kazakhstan, according to hydrogeological studies, in a number of regions of Pavlodar, Almaty, Turkestan and other regions of the Republic of Kazakhstan there are a large number of artesian and geothermal wells with sufficient debit of self-draining water and temperatures from +200˚C to 450°C.

Over the past few years, scientists of the L.N. Gumilev ENU, together with Russian colleagues (NRU “MEI”, KGEU), have been conducting research on the prospects for the use of TN using both the heat of groundwater and reservoirs. There is geothermal heat of water from wells, and the heat of sewage treatment plants, ventilation emissions of buildings, waste heat of a number of industrial enterprises [9, 10].

As a result of carrying out in 2010–2021 at the Research Institute of “Energy Saving and Energy Efficient Technologies” (hereinafter – the Research Institute “Ei ET”) L.N. Gumilyov ENU offers a specific result, a sample of a new product – TN in a block – modular layout. It is one of the main components of an autonomous power supply complex (AEC) using alternative energy sources, for the implementation of a number of state-funded and contractual research works (R&D).

The AEC is based on the basic heat pump technology for converting low-potential heat from low-temperature energy resources (waste heat from self-discharging geothermal wells in a number of regions of the Pavlodar region and other regions of Kazakhstan) into high-potential thermal energy suitable for practical use. It is not another modernization of traditional energy sources, but the introduction of a new, progressive, highly efficient and environmentally friendly method of obtaining heat.

The most important prerequisite for the use of AEC are sufficiently large volumes of low-potential heat lost with water from self-draining geothermal wells in various regions of the Republic of Kazakhstan.

For the first time, a specific technology and schemes for the use of AEC with the use of geothermal wells in the region at temperatures from +250˚C to +450˚C as a source of heat energy are proposed for practical implementation at social and agricultural sector facilities in pilot rural settlements of the Pavlodar region.

AEC using alternative energy sources in a stationary or modular configuration is a metal insulated container.

The practical implementation of the proposed energy-saving and environmentally friendly technology complies with the Laws of the Republic of Kazakhstan "On Energy Conservation and Energy Efficiency Improvement" (2012), "On Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change" (2009). There is the Law of the Republic of Kazakhstan "On Alternative Energy Sources" (2022), the Doctrine of (Strategies) of the Republic of Kazakhstan on achieving carbon neutrality (2022), the tasks of the transition of the Pavlodar region to the introduction of "green" technologies in various sectors of the economy.

Studies conducted in the period from summer 2018 to February 2022 have shown that the use of UEC will ensure reliable and uninterrupted power supply of facilities in rural areas.

For example, in the village of Konstantinovka of the Uspensky district of the Pavlodar region, the millionaire collective farm "30 years of the Kazakh SSR", previously known in the USSR, was located with a centralized heat supply system for the entire infrastructure of the village from the boiler house. Currently there are a number of peasant and farm farms for processing agricultural products, a number of public sector facilities (school, hospital, kindergarten, sports complex, 24-apartment residential building), which have serious problems with heating and hot water supply.

At the same time, according to the akimat of the Ravnopolsky rural district, which includes the village of Konstantinovka, there are 13 self-emptying artesian wells with a large water debit and a sufficiently high temperature in the district.

In 2018-2021 (according to preliminary agreements with regional akimats and orders of small and medium-sized businesses) it is proposed to use AEC for the use of waste heat from geothermal wells on a number of real objects in rural settlements of the Pavlodar region. They significantly reduce thermal pollution of the environment, obtain heat of high parameters for reliable and uninterrupted heat supply of objects in rural settlements.

When introducing AEC in the agro-industrial complex, housing and communal services, public sector facilities of rural settlements of the Republic of Kazakhstan, it is planned to obtain a significant economic and environmental effect, primarily by replacing traditional heat sources (solid, liquid fuel boilers, electric boilers), reducing greenhouse gas emissions into the atmosphere.

The use of autonomous technologies based on AEC will make it possible to return significant volumes of irretrievably lost heat to the heat supply system of objects (agro-industrial sector, social facilities, housing and communal sector, small and medium-sized businesses) without additional burning of traditional fuels. It will allow one to obtain a significant economic effect, to abandon, in some cases, purchased energy from outside, reducing thermal pollution of the environment.

At the same time, all recycled waste heat can be directed to the thermal and scheme of enterprises for heating and hot water at the above facilities, which, in the end, will enable significant savings in heat and electric energy purchased from local boiler houses.

It should be noted that the cost of own heat pump heat will be 2–4 times less than the price of purchased heat, i.e., with the launch of the AEC, there is a real opportunity to meet the existing demand for heat and electric energy for rural commodity producers, social facilities in rural areas at significantly lower costs.

## 3 Results and discussion

Below are the results of the enlarged calculations of the economic effect of the introduction of AEC for social facilities (school, hospital, kindergarten, 24-apartment building), for which the total heat load is 0.683 Gcal/hour (data from Akimat the village of Konstantinovka).

Initial data:

1. The existing source of heat supply is a new modular boiler house on solid fuel (Ekibastuz coal)

The fuel consumption in the boiler house for the heating season, tons – 870.

The cost of fuel for the heating season, Stopl., thousand tenge - 8,127.00.

The price of fuel, Coal, tenge/ton – 8,127,000 / 870 = 9,341.

The duration of the heating period is 210 days.

The cost of 1 kW of electricity, tenge/kWh – 21.56.

The name of the objects that are heated from a modular boiler room:

– Konstantinovskaya secondary school, heated area of Sot. $m^2$ – 3,493.4;

– sports complex, Sot., $m^2$ – 1 617.3;

– nursery-garden "Aigolek", Sot., $m^2$ – 1 010.1;

– 24-apartment residential building, Sot. $m^2$ – 1 124.3; there is no heating, a project with a modular coal boiler is currently being developed.

The total heated area from the modular boiler house, Sot. $m^2$ – 6 120.8.

To compare the efficiency and performance of the existing modular coal boiler house for the heat supply of all the above facilities we proposed block-modular heat pump unit (BMTU) an alternative heat supply system using the heat of geothermal sources the village of Konstantinovka. An enlarged calculation of both options was carried out based on the initial data provided by the Customer for these objects

### 3.1 Modular coal boiler house

The average annual consolidated operating costs for the boiler house will be, tenge/year:

Saved per year = Fuel saved + Saved wages + Saved fee. = 14 728.62 thousand tenge/year.

Autonomous Power Supply Complex (AEC)

Based on the data provided on the heated areas of the facilities, 1 water-to-water heat pump GSHP-400 (PRC) with a thermal capacity of 472 kW was selected for the installation, which is sufficient to cover the specified thermal load of the facility.

The placement of the necessary basic technological and auxiliary equipment is offered in the BNTU on the basis of a 40-foot container.

In the proposed version of the project, as a low-potential source of heat, it is proposed to use the water heat of a geothermal well in the village of Konstantinovka with a temperature of about +280˚C.

In the enlarged calculations, we assume that the total annual operating costs when using AEC based on BNTU are equal to:

Saved AEC = electricity saved + service is saved. = 5,837,430 tenge/year.

The annual savings from the use of AEC compared to the existing heat supply system, tenge / year, is defined as:

Saved = Saved per year – Saved AEC = 8,891 190 tenge/year.

In fact, the total annual effect will be greater if the actual operating costs of the coal boiler house are fully taken into account (taking into account the specified costs for the purchase of coal, equipment repair costs, personnel payments, environmental payments).

The data of the enlarged calculations compared to 2 sources of heat supply of social facilities in the village of Konstantinovka are shown below in Table 1.

**Table 1**. Comparison of annual operating costs of facilities in the village of Konstantinovka, Uspensky district, Pavlodar region for heat supply from various heat sources (thermal load - 0.683 Gcal/hour).

| No. | Name of the heat source | The cost of annual operating costs, Saved per year, thousand tenge* | Cost 1 Gcal/hour, tenge/Gcal (including VAT) |
|---|---|---|---|
| 1 | Modular boiler room The village of Konstantinovka | 14 728,62 | 12 742 |
| 2 | Autonomous power supply complex | 5 837,43 | 856 |

* The data are given for January 2022; the exchange rate is $1 = 432 tenge.

During recent meetings (February 15–16, 2022) of representatives of the Research Institute “Ei ET” with the leadership of the akimat of the Uspensky district, Ravnopolsky rural district, representatives of small and medium-sized businesses, the use of AEC using alternative energy sources was proposed. It is a solution to the problem of reliable and uninterrupted provision of heat supply to the village of Konstantinovka.

A Memorandum of cooperation, a Letter of Intent, and an agreement on co-financing of this project were signed with the Akimat of the Uspensky district.

Similar documents were signed with representatives of small businesses in the region (FH “Oynak”) concerning energy supply with the use of AEC of a greenhouse complex under construction, a shift settlement of 8 houses in the above-mentioned rural district.

The technical solutions are proposed by the scientists of the Research Institute “Ei ET” of the University for a specific pilot region (Uspensky district – the border of the Kachir district) of the Pavlodar region. It will allow one to breathe life into these settlements in the shortest possible time, since there are dozens of geothermal wells in the region with a self-draining water temperature of about 250˚C – 450˚C and with a water debit of 15 $m^3$/hour up to 75 $m^3$/hour.

Based on the results of the previous research conducted by the staff of the Research Institute "EiET" of the L.N. Gumilev ENU, we can safely say the following. The large-scale use of AEC using alternative energy sources in stationary or modular configuration in various regions of the country will help to solve problems in rural settlements with heat cooling and electricity supply of the agricultural sector and social (budgetary) facilities spheres.

Thus, the source of profitability of projects when implementing the UEC at various facilities of the agricultural sector (greenhouses, meat and dairy enterprises, vegetable and fruit storage facilities) and public sector facilities (schools, hospitals, kindergartens, sports complexes, administrative buildings and structures, etc.) are:

1. Significant economic effect, i.e., the difference in the cost of thermal energy purchased by consumers from boiler houses and produced with the use of AEC (3−5 times).
2. A significant reduction in the operating costs of the above facilities using alternative energy sources for heat and cold supply.
3. Reduction of greenhouse gas emissions in rural areas and, as a result, reduction of environmental payments of economic entities.

## 4 Conclusion

This article discusses the issues of the application of AEC using the heat of geothermal sources to improve the efficiency of heat supply systems for social facilities, agro-industrial complex, small and medium-sized businesses in a particular region of the Republic of Kazakhstan.

A real technology and schemes for the application of AEC using geothermal wells with t from +250˚C to +450˚C as a source of heat energy are proposed for implementation at social and agricultural sector facilities in pilot rural settlements of the Pavlodar region and other regions of the Republic of Kazakhstan.

When applying the proposed technology in various regions of the Republic of Kazakhstan, a significant economic and environmental effect is expected primarily due to the replacement of traditional heat sources (solid and liquid fuel boilers, electric boilers), reduction of greenhouse gas emissions into the atmosphere and improvement of the environmental situation.

The results of calculations of the economic effect of the introduction of TN for the heat supply of a number of social facilities (school, hospital, kindergarten, 24-apartment building, sports complex) of a pilot settlement in the Republic of Kazakhstan with a total heat load of 0.683 Gcal/hour are presented.

## References

1. G. V. Safonov, B. Yesekina, Sh., Tuebekova, Decarbonization of the national economy: strategies and scenarios, *Proceedings of the National Academy of Sciences of the Republic of Kazakhstan. A series of social sciences and humanities,* **313 (3),** 13–22 (2017)
2. S. Zh. Daukeeva (Ed.) *Decarbonization of extractive industries of the Republic of Kazakhstan* (Nur-Sultan: Bi-PRINT, 2021).
3. S. Daukei (Ed.) *Decarbonization of Economy's Extractive Sectors of the Republic of Kazakhstan* (Nur-Sultan: Bi-PRINT, 2021)
4. D. Ray, D. McMichael, *Heat pumps* (Moscow: Energoizdat. 1982)
5. G. Heinrich et al. *Heat pump installations for heating and hot water supply* (Moscow: Stroyizdat, 1985)
6. G. P. Vasiliev, Geothermal heat pump systems of heat supply, *Thermal power engineering*, **6,** 33–41 (2004)
7. T. G. Kuzmina, Energy saving during trigeneration in technologies with circulating water supply, *Turbines and Diesels*, *July – August*, pp. 12-14, (2012)
8. A. Sh. Alimgazin, S. G. Alimgazina, Heat pump technologies for heat supply of various objects. Experience of the Republic of Kazakhstan, *AVOK, Energy saving***, 8,** 68–73, (2013)
9. A. Sh. Alimgazin, I. A. Sultanguzin, Yu. V. Yavorovsky, I.G. Akhmetova, A. N. Berguzinov, Prospects of using absorption heat transformers to improve energy efficiency of industrial enterprises of the Republic of Kazakhstan, *Bulletin of Toraighyrov University. The Energy series* **4,** 21–33 (2020).
10. K. V. Alexandryan, R. G. Hanoyan, The use of low-potential heat for heating greenhouses, **3,** 6–8 (2002)
11. E. V. Shushunova, Efficiency of using heat pumps for cooling milk and heating water at livestock complexes of the agro-industrial complex: PhD dissertation (Moscow, 2012)
12. Aerocond Moscow, Retrieved from: http://www.aerocond.ru
13. A. G. Pozdnyakov, V. A. Shchelkanov, A. A. Gridnev, Absorption bromistolithium refrigerating machine ABHM-1000VN in the trigeneration system of a greenhouse plant. *Energy saving* **7,** 56–64, (2009)
14. Annual Message to the people of Kazakhstan of the First President of the country on the launch of a new special project "Auyl-El besigi" within the framework of the program "Rukhani Zhangyru" (Nur-Sultan, 2019)